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Study of the Life History and Spotting Habits of *Eutettix chenopodii* (Homoptera, Cicadellidæ).*

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INTRODUCTION.

HISTORICAL SKETCH.

OSBORN (1), in 1887, was the first to associate the characteristic spotting on *Chenopodium album* with the leaf hopper, *Eutettix strobi* Fitch. He considered the reddish injury on the plant a natural protection to the reddish nymphs of this species. Brunner (2), in 1891, stated that this species was "very partial" to *Chenopodium album* and described its injury. Forbes and Hart (3), noted that " it causes the dark purple spotting often seen on the leaves of lamb's-quarter, and probably a similar discoloration common on

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beet leaves." Ball (4), in 1907, stated that the nymphs live on lamb's-quarter, where their punctures cause purple spots on the leaves. He found there were two broods in a season, adults appearing in June and again in August. Fenton (5), in 1924, described the injury as a series of distinct crimson-colored spots more or less circular in outline, the tissue of the leaf being convex in the discolored area. Spotting was found to be more distinct on the lower side where the areas were concave. The spots were located at any point on the leaf that might become confluent. The margin of the affected leaves curled under and the plants became stunted and dwarfed. His attempts to rear a third generation in 1920 failed. Lawson (6), in 1920, reported this species producing purple spots on *Chenopodium* in a widely distributed area in the state of Kansas.

METHODS OF STUDY.

This study on the life history and spotting habits of *Eutettix chenopodii* Osborn, formerly called *Eutettix strobi* (Fitch), extended from May 28 to September 15, 1926. Both adults and nymphs of the first generation were observed in the vicinity of the University of Kansas, chiefly on lamb's-quarter (*Chenopodium album* L.), which grew abundantly along the Kansas river.

Observations were made from specimens collected and reared on various plants in the insectary. Daily records were kept, and in some instances two or three observations were made within a twenty-four hour period.

Lamb's-quarter, pigweed (*Amaranthus hybridus* and *A. blitoides*) and purslane plants (*Portulaca oleracea*) were secured from localities free from *Eutettix chenopodii.* All other plants used were grown from seed.

An attempt was made to rear *Scaphoideus* nymphs found on the same plants and under the same conditions as *Eutettix chenopodii* but these all proved unsuccessful. Evidently these nymphs, while living sometimes on the same hosts, obtain their food from other plants, as all that were started in the insectary died within a few days.

In the study of the injury produced on the leaves of the host plants, the greatest of care was exerted in order to avoid any possible infestation of healthy plants from infected ones. Controls were run along with each host plant used, and in no case did these reveal spotting or signs of curling.

LIFE HISTORY NOTES.

DESCRIPTION OF SPECIES.

Dr. P. B. Lawson, in his paper on the Cicadellidæ of Kansas, gives the following description of this species:

"Form: Length, 4.5 to 5.25 mm. Vertex one-fourth longer on middle than next the eye, two and one-half times as wide as long, with a faint transverse depression, and broadly rounded apically. Pronotum over twice as wide as long, lateral margins rather short. Elytra moderately long.

"Color: Vertex, pronotum and scutellum varying from yellowish irrorate with brown to reddish brown. Elytra usually milky white with bands of brown at base, and across apical half of clavus. Frequently these bands are so run together as to give the entire elytra a brownish appearance. Face the color of the vertex.

"External genitalia: Female, last ventral segment long, lateral angle broadly rounding, posterior margin notched on either side of a small median notched lobe which gives the appearance of two median teeth; pygofers broad, nearly or quite equalling the ovipositor, sparsely spined. Male, valve broad, rounded posteriorly; plates broad basally, then rapidly narrowed, ending in elongate filamentous tips which exceed the pygofers.

"Internal male genitalia: Styles large, triangular, broad basally, terminal process slightly convex on mesal margin, posteriorly straight on outer margin; connective very stout, Y-shaped, arms about equalling the basally broadened stem; œdagus with a wide, dorsal process to anal tube membrane, terminal portion composed of a broad median straplike and terminally bifid process and a pair of lateral narrower and acutely pointed processes."

DISTRIBUTION.

Specimens have been examined from Massachusetts, Connecticut (Britton), New York (Van Duzee), Niagara, Canada (Osborn), Pennsylvania (Wirtner), Ohio (Osborn), Iowa (Osborn, Ball), Missouri (Heid. coll., Osborn coll.), Nebraska (Bruner), Kansas (Snow, Crev.), Colorado (Gill., Ball), Utah (Ball), Texas (College Station, Sanderson; Victoria, U. S., N. M.)

Chenopodium album is a native of Europe and is introduced everywhere in this country. Undoubtedly the distribution of this insect is limited only by the range of this plant.

This species is one of the most widely distributed of the leaf hoppers in Kansas. Dr. P. B. Lawson has noted them in eighteen counties across the state. The writer has observed many of them, also, in two more counties, Wyandotte and Leavenworth.

HOSTS.

This species may be found on a number of hosts. Lamb's-quarter (*Chenopodium album*) is its normal host, but it will live and pro-

duce the same results on beet (*Beta vulgaris*), and chard (*Beta vulgaris*, var. *cicla*) and pigweed (*Amaranthus hybridus* and *A. blitoides*). In the field, nymphs have also been observed spotting purslane (*Portulaca oleracea*) and wormseed (*Chenopodium ambrosioides* var. *anthelminticum*). In the insectary, the insect was reared on all the above plants except the wormseed. Observations in the field revealed the characteristic markings also on another pigweed (*Amaranthus retroflexus*) and peppergrass (*Lepidium virginicum*).

HIBERNATION.

Nymphs in the third, fourth and fifth instars were observed in the field as late as September 15. In all probability, all of those that emerged as adults were the ones to overwinter. It is thought they overwinter under grass and leaves on the ground.

MATING AND OVIPOSITION.

In producing a third generation, seventy-six pairs of mated adults were caged on the various host plants (charts 1-5). The period of copulation varied from forty minutes to two hours and forty minutes. One pair of adults was observed to mate within a few hours of their emergence into the adult stage. Adults mated but once. Ovipositing was watched both in the field and in the insectary and the following observations made:

CHART I.—Mated adults on beet (*Beta vulgaris*).

Cage No.	Emergence of adults.	Placed in cage.	Mating.	First appearance and number of eggs.	First hatching and number of eggs hatched.	Preoviposition.	Total number of eggs hatched.	Condition of plant.	History of mating adults.
1	7–16–26	7–16–26		7–19–26 1	7–28–26 1	3	12	1 leaf curling where egg had been placed 7–17–26. 3 spots on 1 leaf 8–8.	Male dead 7–19. Female dead 8–7.
2	7–16	7–16		7–23 3		7		Leaves containing eggs all eaten on edges where eggs were 9–14.	Male dead 7–17. Female escaped.
3	7–16	7–16		7–23 13	7–28 12	7	25	1 leaf curled 7–17. 1 leaf dead 7–29. 2 leaves dead 8–4.	1 adult partly eaten by pill bugs 7–27. 1 adult missing 7–29.
4	7–16	7–16		8–1 2		16		Leaves containing eggs eaten 9–14.	Male dead 7–20. Female placed in cage to hibernate 8–13.
5	7–16	7–16		7–19 4	7–29 2	3	43	1 spot in large leaf 8–2. 1 spot in large leaf 8–12.	Adults placed on beet 7–31.
6	7–17	7–17	7–19 10:20 a. m.	7–22 5	8–1 3	5	8	1 leaf dried 7–26. 1 leaf dried and curling 7–27. 1 leaf dried and yellow 7–28. 1 spot in 1 leaf 8–2. Plant dead 8–11.	1 adult missing 7–31. 1 adult placed in cage to hibernate 8–11.
7	7–29	7–29						Only one leaf left on plant 8–7. Plant almost dead 8–13.	Female dead 8–5. Male dead 8–9.

CHART I.—Mated adults on beet—CONTINUED.

Cage No.	Emergence of adults.	Placed in cage.	Mating.	First appearance and number of eggs.	First hatching and number of eggs hatched.	Preoviposition.	Total number of eggs hatched.	Condition of plant.	History of mating adults.
8	7–29..... Reared from second generation on lamb's-quarter, 4.	7–29	.....	.....	.....	.....	.....	2 leaves dead 8–1. Given new plant 8–3. Second plant dead 8–8.	Female dead 8–1. Male dead 8–4.
9	7–29..... Reared from second generation on lamb's-quarter, 4.	7–29	.....	8–3 5	.....	5	2	1 small leaf half eaten 8–13. 1 leaf dried up and 4 spotted by nymphs 9–17.	Adults placed in cage to hibernate 9–17.
10	7–29..... Reared from second generation on lamb's-quarter, 13.	7–29	.....	8–4 2	8–12 1	6	19	3 leaves 7-8 spotted by the nymphs left on 9–17.	Adults dead 9–17.
11	7–29..... Reared from second generation on lamb's-quarter, 13.	7–29	.....	8–9 10	.....	11	.....	1 leaf dead 8–4. Eggs in leaves eaten 9–17.	1 adult escaped 9–17. 1 adult dead 9–17.
12	8–3..... Reared from second generation on lamb's-quarter, 13.	8–3	8–5 9:40 a. m.	8–9 13	.....	6	23	Leaves quite spotted by nymphs and turning yellow, some dead 9–17.	Adults dead 9–17.
13	8–3..... Reared from second generation on lamb's-quarter, 4.	8–3	.....	.....	.....	.....	.....	Plant alive 9–17.	Adults dead 9–17.
14	8–7..... Reared from second generation on lamb's-quarter, 4.	8–7	.....	.....	.....	.....	.....	Plant dying 9–17.	Adults dead 9–17.

CHART I.—Mated adults on beet—CONCLUDED.

Cage No.	Emergence of adults.	Placed in cage.	Mating.	First appearance and number of eggs.	First hatching and number of eggs hatched.	Preoviposition.	Total number of eggs hatched.	Condition of plant.	History of mating adults.
15	7–31..... From beet, 5.	7–31	.....	8–3 6 or 8	.....	 3	.....	Plant dying 8–5. Plant dead 8–9.	Adults dead 8–6.
16	7–26..... 2 Mating pair.	7–26	.....	.....	.....	.....	.....	.....	Female dead 7–31. Male missing 8–12. Female dead 8–13. Male placed in cage to hibernate 8–13.
17	7–26..... 2 Mating pair.	7–26	.....	8–3 (few)	.....	 8	 5	1 lower leaf dying 8–4. 1 leaf dying 8–5. Given new plant 8–6.	Female dead 7–28. Male dead 8–9. 1 adult dead 9–14. 1 adult placed in cage to hibernate 9–14.
18	7–31..... 2 Males and 1 female.	7–31	.....	.....	.....	.....	.....	.....	Male missing 8–11. Male and female placed in cage to hibernate 8–13.
19	8–9..... Pair from pigweed. 2.	8–9	.....	8–12 (few)	.....	 3	.....	.....	Adults placed in cage to hibernate 8–13.

CHART II.—Mated adults on chard (*Beta vulgaris* var. *Cicla*).

Cage No.	Emergence of adults.	Placed in cage.	Mating.	First appearance and number of eggs.	First hatching and number of eggs hatched.	Preoviposition.	Total number of eggs hatched.	Condition of plant.	History of mating adults.
1	7–16	7–16		7–22 2 7–30 12 (On third plant)	8–10 4	 6 14	 7 	Plant dead; given new plant 7–20. Second plant dead, with eggs eaten 8–1. All other leaves with eggs eaten 8–13.	Female dead 8–5. Male dead 8–12.
2	7–16	7–16						Plant dried; given new plant 7–20. Plant dead 7–29.	1 adult dead 7–23. 1 adult escaped 7–24.
3	7–16	7–16	7–18 6:30 p. m.	7–21 10 or 12	8–1 1	 5	 25	Edges of several leaves eaten by pill bugs 7–30. Several more eaten 8–1. Plant healthy 8–13.	Adults placed on chard 15, 8–1.
4	7–16	7–16		8–11 Several		 26		4 leaves dead 7–29. Stem eaten 8–3. Plant broken 8–13.	Male dead 7–23. Female placed in cage to hibernate 8–13.
5	7–16	7–16						Plant healthy 8–13.	Male escaped 7–24. Female placed in cage to hibernate 8–13.
6	7–16	7–16						Plant rotted at ground 7–19.	Female dead 7–17. Male dead 7–19.
7	Male 7–21 Female 7–22	7–22						Plant healthy.	Adults placed in cage to hibernate 7–18.

CHART II.—Mated adults on chard—CONCLUDED.

Cage No.	Emergence of adults.	Placed in cage.	Mating.	First appearance and number of eggs.	First hatching and number of eggs hatched.	Preoviposition.	Total number of eggs hatched.	Condition of plant.	History of mating adults.
8	7–21	7–22	7–23 8:30 a. m.	7–28 12				1 leaf dried 7–30. Plant drying 7–31. Plant dead 8–2.	Adults placed on chard 14.
9	7–22	7–22		7–30 3	8–10 3	8	8	Leaves with eggs eaten 8–13.	Female missing 8–22. Male placed in cage to hibernate 8–13.
10	7–29	7–29		8–2 2	8–11 1	4	3	Leaves badly eaten by pill bugs 8–13. Leaves with eggs eaten 8–4.	Male missing 8–11. Female placed in cage to hibernate 8–13.
11	7–29	7–29						Plant dying 8–4. Plant dead 8–13.	Male missing 8–12. Female placed in cage to hibernate 8–13.
12	7–29	7–29						Plant healthy 8–13.	Male missing 8–2. Female placed in cage to hibernate 8–13.
13	7–23 2 pair	7–23	7–29 9:05 a. m. till 9:45 a. m.	7–30 (few)	8–9 1	7	23	1 leaf 18 spots, large; 1 leaf 69 spots and 5 large areas that are red; 1 leaf 93-100 spots. These made by nymphs left on plant 9–14.	Male partly eaten 8–5. Female escaped 8–9. Male eaten 8–12. Female placed in cage to hibernate 8–13.
14	7–31 From chard 8	7–31 From chard 8		8–4 (few)	8–13 1	10 (?)	1	Leaves eaten 8–10. Leaf with many eggs eaten 8–12.	1 adult dead 8–12. 1 adult escaped 8–12.
15	8–1	From chard 3		8–6 (few)	8–13 2	5?	2	Plant healthy.	Adults placed in cage to hibernate 8–13.

CHART III.—Mated adults on lamb's-quarter (*Chenopodium album*).

Cage No.	Emergence of adults.	Placed in cage.	Mating.	First appearance and number of eggs.	First hatching and number of eggs hatched.	Preoviposition.	Total number of eggs hatched.	Condition of plant.	History of mating adults.
1	7–16.....	7–16	.....	7–21 4	7–30 3	 5	 23	Plant healthy 8–13.	1 adult missing 7–31. 1 adult dead 7–26.
2	7–16.....	7–16	.....	.....	.....	.....	.....	Few leaves dropped off 8–3.	Male dead 7–17. Female escaped 7–22.
3	7–16.....	.....	.....	.....	.....	.....	.....	1 leaf eaten 7–30.	Male dead 7–28. Female escaped 7–31.
4	Male 7–16..... Female 7–17	7–17	.....	7–26 3	7–30 1	 9	 1	Plant healthy 8–13.	Both escaped 7–23.
5	Male 7–16..... Female 7–17	7–17	.....	7–26 3	7–30 1	 9	 1	Plant healthy 8–13.	Both dead 7–21.
6	7–20.....	7–21	.....	.....	.....	 13	.....	Plant healthy 8–13. No change in plant 9–14.	Male dead 7–30. Female dead 8–13.
7	7–20.....	7–21..	.....	.....	.....	.....	.....	White spots on leaves 7–30. Plant healthy 8–13.	1 adult dead 7–28. 1 adult dead 7–29.
8	7–31..... From second generation on lamb's-quarter, 4.	7–31	.....	.....	.....	.....	.....	Plant healthy 8–13.	Adults dead 8–4.
9	7–31..... From second generation on lamb's-quarter. 13.	7–31	.....	.....	.....	.....	.....	Plant healthy 8–13.	Female dead 8–5. Male dead 8–11.

CHART III.—Mated adults on lamb's-quarter—CONCLUDED.

Cage No.	Emergence of adults.	Placed in cage.	Mating.	First appearance and number of eggs.	First hatching and number of eggs hatched.	Preoviposition.	Total number of eggs hatched.	Condition of plant.	History of mating adults.
10	7–31..... Lamb's-quarter 13, same as (9).	7–31	.....	8–13 (†)	.....	13	14	Plant much spotted and turning yellow 9–17.	Adults dead 9–17.
11	7–29..... 2 females and 1 male from lamb's-quarter 4, second generation	7–29	.....	.....	.....	.....	.....	Plant healthy 8–13.	Female dead 8–1. Male missing 8–4. Female dead 8–8.
12	1 male and 1 female 7–20..... 1 female 7–21	7–21	.....	.....	.....	.....	.....	Plant healthy 8–13.	1 dead 7–25. 1 dead 7–26. 1 dead 7–27.
13	1 male and 1 female 7–22..... 1 female 7–21	7–22	.....	.....	.....	.....	.....	Yellow spots in few leaves 7–30.	Male dead 7–25. Female dead 7–30. Female missing 8–4.
14	7–26..... 3 females and 1 male	7–26	.....	7–29 5	.....	7	.....	2 lower leaves yellow 8–12. Plant alive 9–17.	1 adult missing 7–31. 1 adult dead 9–14. 2 adults placed in cage to hibernate 9–14.
15	8–6..... From pigweed, 7.	8–6	.....	.....	.....	.....	.....	Plant healthy 8–13.	Adults eaten 8–11.
16	7–23..... 2 pair.	7–23	8–10 9:53 a. m.	8–1 (few)	.....	14	.....	Leaf at bottom dried 7–27. Leaf at bottom dead 7–29. Plant dead 9–14.	Adults placed in cage to hibernate 8–13.
17	8–8..... From pigweed, 5.	8–8	.....	.....	.....	.....	.....	Plant healthy 8–13.	Male dead 8–10. Female dead 8–11.

CHART IV.—Mated adults on pigweed (*Amaranthus hybridus*).

Cage No.	Emergence of adults.	Placed in cage.	Mating.	First appearance and number of eggs.	First hatching and number of eggs hatched.	Preoviposition.	Total number of eggs hatched.	Condition of plant.	History of mating adults.
1	7–13.....	7–13	7–13 10:40 a. m. to 1:20 p. m.	7–16 8	7–25 3	12	8	Leaves falling 7–28. All leaves gone from plant 8–2.	Male dead 7–16. Female dead 7–19.
2	7–20.....	7–20	.....	7–30 6	8–9 3	 9	 17	Plant healthy.	Adults placed on beet, 12, 8–9.
3	7–19.....	7–19	.....	.....	.....	.....	.....	Holes in lower leaves 7–30.	Female dead 8–1. Male dead 8–11.
4	7–19.....	7–19	.....	.....	.....	.....	.....	2 leaves eaten 7–23. Holes in leaves 7–26.	Male dead 7–23. Female missing 7–23.
5	Male 7–21..... Female 7–20	7–21	.....	7–30 2 or 3	8–10 1	 8	 1	Leaves eaten on edge 7–30. 1 leaf dropped off 7–31. 1 leaf with eggs eaten 8–8. Plant dried entirely 9–17.	Adults placed on Pursley, 7, and died 8–10.
6	7–21.....	7–21	.....	7–26 5	8–6 2	 5	 29	1 leaf turning yellow 7–30. Leaves eaten on edge 8–2.	Adults placed in lamb's-quarter, 12, 8–6.
7	Male 7–21..... Female 7–20	7–21	.....	7–29 4	8–8 3	 8	 28	Several leaves eaten.	Male escaped 7–30. Female placed in cage to hibernate 8–13.

CHART IV.—Mated adults on pigweed—CONCLUDED.

Cage No.	Emergence of adults.	Placed in cage.	Mating.	First appearance and number of eggs.	First hatching and number of eggs hatched.	Preoviposition.	Total number of eggs hatched.	Condition of plant.	History of mating adults.
8	From second generation on lamb's-quarter, 13.	8–3	.....	.....	.....	.....	.....	Plant alive 9–17.	Adults dead 9–17.
9	7–21..... 1 male and 2 females.	7–21	.....	7–30 4 or 5	8–8 5	 8	 18	Edges of 4 leaves eaten 7–30. Leaves with eggs eaten 8–12.	Female escaped. Male and female placed on lamb's-quarter, 13.
10	7–31..... 2 pair.	7–31	.....	7–11 (few)	.....	 11	.....	Plant healthy 8–13.	Female dead 8–6. Male dead 8–10. 2 adults partly eaten 8–10.

CHART V.—Mated adults on purslane (*Portulaca oleracea*).

Cage No.	Emergence of adults.	Placed in cage.	Mating.	First appearance and number of eggs.	First hatching and number of eggs hatched.	Preoviposition.	Total number of eggs hatched.	Condition of plant.	History of mating adults.
1	Male 7–16..... Female 7–17	7–17	.....	.....	.....	.....	.....	Brown spots in a few leaves 7–26. Plant healthy 8–13.	Adult dead 7–20. Adult dead 7–22.
2	Male 7–19..... Female 7–18	7–19	.....	.....	.....	.....	.....	Plant healthy 8–13.	Both dead 7–20.
3	Male 7–19..... Female 7–18	7–19	.....	7–23–26 12	.....	 4	.....	Leaf with eggs broken from plant 8–2. Plant healthy 8–13.	Boath dead 7–26.
4	Male 7–20..... Female 7–18	7–20	.....	.....	.....	.....	.....	Plant healthy 8–13.	Both dead 7–23.
5	7–26.....	7–26	.....	.....	.....	.....	.....	2 large leaves decayed 8–1. Plant dead 8–3.	Both dead 7–31.
6	7–28..... 2 pair	7–28	.....	.....	.....	.....	.....	Plant healthy.	Female missing 7–30. Male dead 7–30. Female dead 8–1. Male missing 8–6.
7	Male, lamb's-quarter, 13. 2 females lamb's-quarter, 4. From second generation.	8–3	.....	.....	.....	.....	.....	Plant healthy 8–13.	Male and female dead 8–8. Female placed in cage to hibernate 8–13.
8	7–28..... 2 pair	7–28	.....	.....	.....	.....	.....	Several leaves 7–30.	Male dead 7–30. Female dead 8–1. One missing 7–30. 1 placed in cage to hibernate 8–13.
9	8–7..... From pigweed. 5.	8–7	.....	.....	.....	.....	.....	Plant healthy 8–13.	Adults dead 8–10.

OBSERVATIONS ON EGG LAYING. The eggs are inserted in the tissues of the upper surface of the leaf, just under the epidermis. The female slowly creeps to the edge of the leaf and places her front pair of legs, one on one side of the leaf and the other on the opposite side just a short distance past the edge. After placing the beak on the edge of the leaf to brace herself firmly, the body is bent so as to bring the tip of the abdomen down, with the ovipositor just touching the surface of the leaf. The inner valves of the ovipositor are then unsheathed from the outer ones and by a sawing movement a small slit is made in the epidermis. By grasping the leaf more firmly with the hind legs, the ovipositor is inserted its whole length into the opening already made. The egg passes between the valves of the ovipositor into the small chamber made for it, and the ovipositor is withdrawn and again sheathed. She may repeat this process in a few seconds or may wait several hours.

POSITION OF THE EGGS. From 30 to 120 seconds are usually consumed in placing one egg. Most of this time is used in preparing the chamber. The eggs have no special arrangement. Sometimes they are in rows, but usually they are placed singly and irregularly, although they may touch each other at the ends. However, each egg is placed in a separate puncture. They may be placed anywhere on the flat surface of the leaf as well as near the edge. Observations on beet and chard revealed eggs and egg punctures quite numerously at the base and the petiole in preference to the leaf edge.

NUMBER OF EGGS. The largest number of eggs from one female adult was forty-three and the smallest number was one. Only twenty-six pairs of the mated adults produced eggs. The number of eggs in one leaf varied from one to eighteen according to the size of the leaf. The average number of eggs that hatched from twenty-four pairs of adults was fourteen. One hundred forty-six eggs were laid on beet leaves and forty on lamb's-quarter. Eggs were found on all of the hosts with the exception of purslane.

EFFECT OF OVIPOSITION ON THE LEAVES. Oviposition affects the leaves but slightly. The small punctures or egg chambers turn white or yellow, but otherwise the leaf grows naturally and appears normal, unless it is quite small and has very many punctures made in it.

PREOVIPOSITION PERIOD. From chart 6 the preoviposition period, the length of the egg stage, and the number of eggs hatched may be obtained.

CHART 6.—Showing the length by days of preoviposition period, length of egg stages, and number of eggs hatched by mated adults of the third generation from July 16 to September 14, 1926.

PLANT	Cage No. of mated adults.	Preoviposition period.	Egg stage.	Number of eggs hatched.
Beet	1	3	9	12
	2	7		
	3	7	5	25
	4	16		
	5	3	10	43
	6	5	10	8
	9	5		4
	10	6	8	21
	11	11		
	12	6		27
	17	8		6
Total		77	42	146
Average		7	8.4	18.2
Chard	1	6	11	7
	3	5	11	25
	4	26		
	9	8	11	8
	10	4	9	3
	13	7	10	29
	14		9	1
	15		7	2
Total		56	68	75
Average		9.3	9	10.7
Purslane	3	7		
Total		7		
Average		7		
Lamb's quarter	1	5	9	23
	5	9	4	1
	6	13		
	10	13		16
	14	7		
	15	14		
Total		61	13	40
Average		10.1	6.5	13.3
Pigweed	1	12	9	8
	2	9	10	17
	5	8	11	1
	6	5	11	29
	7	8	10	28
	9	8	9	18
	16	11		
Total		61	60	101
Average		8.7	10	16.8
		31 pairs of mated adults.	20 pairs of mated adults.	24 pairs of mated adults.
Summary:				
Beet		7	8.4	18.2
Chard		9.3	9.7	10.7
Lamb's quarter		10.1	6.5	13.3
Pigweed		8.7	10	16.8
Purslane		7		
General average		8.4	8.6	14.7

From thirty-one mated adults the average length of the preoviposition period on all host plants was 8.4 days. The shortest period was three days, and the longest period twenty-six days. This period was the shortest on beet and the longest on lamb's quarter.

INCUBATION PERIOD. The time required for the incubation of the eggs in the same brood averaged 8.6 days for the eggs from twenty pairs of adults. The shortest incubation period was four days, the longest eleven days. Incubation was completed most quickly, averaging 6.5 days, on lamb's quarter. Ten days were required on pigweed.

EMERGENCE FROM THE EGG. From one to twelve minutes are consumed by the nymphs while emerging from the egg. The head appears first at the tiny opening in the epidermis of the leaf made when the egg was inserted. This is followed by part of the body which sways forward, backward, and sideways every few seconds with brief rest periods in between. Gradually more of the body appears. The first pair of legs are soon dried. As soon as the second pair becomes visible, the nymph widens the angle of swaying, continuing this motion until the first two pairs of legs rest on the surface of the leaf. After firmly securing a foothold, the rest of the body is pulled from the egg with several hard tugs. As soon as completely dry, which is only a few seconds, these small nymphs are able to hop about from one leaf to another. When walking about on a leaf, they frequently go sideways, somewhat similar to a crab.

NYMPHS.

LENGTH OF NYMPHAL LIFE. During their nymphal life, these leaf hoppers molted five times and became adults in thirty-one days in the second generation and thirty-four days in the third generation. Of the eleven individuals of the third generation becoming adults, the average nymphal period was but thirty-two days. (Chart 7.) In the second generation, the shortest nymphal stage observed was twenty days and the longest forty-six days, while in the third generation this stage varied from twenty-five to forty-four days. Chart 8 shows the records and average length of each instar, the tendency being for the life of the instar to lengthen progressively with the age of the nymph.

CHART 7.—Length of instars.

No. of generation.	First instar.			Second instar.			Third instar.		
	Longest.	Shortest.	Average.	Longest.	Shortest.	Average.	Longest.	Shortest.	Average.
Second	*7	*7	7	10	4	6-7	12	3	6.6
Third	18	2	5.8	15	2	5.5	12	2	6.5
Number of nymphs			111			78			52

* One nymph only.

CHART 7.—CONCLUDED.

No. of generation.	Fourth instar.			Fifth instar.			Nymphal period.		
	Longest.	Shortest.	Average.	Longest.	Shortest.	Average.	Longest.	Shortest.	Average.
Second	9	3	5.4	8	3	5.5			31.2
Third	12	4	7.4	14	5	8.7	44	25	33.9
Number of nymphs			26			11			

CHART 8.—Length of instars of third generation.

Number.	1	2	3	4	5	Number.	1	2	3	4	5
1	5	*5	.....	.....	.....	76	6	4	10	*16	.....
2	5	6	4	6	*3	77	5	5	*7	.....	.....
3	*1	.....	.....	.....	.....	78	5	4	8	7	6
4	5	*1	.....	.....	.....	79	6	4	8	*12	.....
5	*3	.....	.....	.....	.....	80	5	3	*8	.....	.....
6	7	4	4	*9	.....	81	5	*1	.....	.....	.....
7	*7	.....	.....	.....	.....	82	4	*6	.....	.....	.....
8	*5	.....	.....	.....	.....	83	6	4	*7	.....	.....
9	*4	.....	.....	.....	.....	84	4	4	5	*3	.....
10	4	*4	.....	.....	.....	85	5	3	*5	.....	.....
11	4	6	3	*10	.....	86	5	3	4	.....	.....
12	5	*2	.....	.....	.....	87	*6	.....	.....	.....	.....
13	5	*1	.....	.....	.....	88	4	5	*3	.....	.....
14	4	5	3	*7	.....	89	*2	.....	.....	.....	.....
15	5	5	4	*9	.....	90	5	*0	.....	.....	.....
16	6	6	3	6	*15	91	6	4	*4	.....	.....
17	4	7	8	9	11	92	*4	.....	.....	.....	.....
18	5	*2	.....	.....	.....	93	7	6	6	6	14
19	7	*4	.....	.....	.....	94	5	6	9	8	.....
20	5	4	4	4	*2	95	6	*8	.....	.....	.....
21	*4	.....	.....	.....	.....	96	5	4	9	10	.....
22	8	4	4	*8	.....	97	7	*1	.....	.....	.....
23	*5	.....	.....	.....	.....	98	6	4	5	7	*7
24	8	5	*1	.....	.....	99	5	5	3	.....	.....
25	*2	.....	.....	.....	.....	100	*1	.....	.....	.....	.....
26	*4	.....	.....	.....	.....	101	6	3	12	*14	.....
27	7	4	3	*10	.....	102	*1	.....	.....	.....	.....
28	*5	.....	.....	.....	.....	103	8	*3	.....	.....	.....
29	*4	.....	.....	.....	.....	104	6	4	11	*11	.....
30	*4	.....	.....	.....	.....	105	5	6	12	12	*0
31	6	*1	.....	.....	.....	106	6	2	*13	.....	.....
32	*4	.....	.....	.....	.....	107	5	5	7	10	*14
33	.....	.....	.....	.....	.....	108	7	*0	.....	.....	.....
34	*3	.....	.....	.....	.....	109	5	5	*3	.....	.....
35	*3	.....	.....	.....	.....	110	4	*7	.....	.....	.....
36	*3	.....	.....	.....	.....	111	5	7	5	6	9
37	6	3	4	*3	.....	112	5	9	6	6	*3
38	*3	.....	.....	.....	.....	113	4	4	7	5	5
39	*3	.....	.....	.....	.....	114	6	7	10	*10	.....
40	*3	.....	.....	.....	.....	115	*3	.....	.....	.....	.....
41	*3	.....	.....	.....	.....	116	5	*14	.....	.....	.....
42	*3	.....	.....	.....	.....	117	5	*8	.....	.....	.....
43	7	4	6	*4	.....	118	6	8	7	*0	.....
44	*2	.....	.....	.....	.....	119	*2	.....	.....	.....	.....
45	6	4	3	8	*5	120	4	6	5	6	6
46	6	4	*5	.....	.....	121	5	*7	.....	.....	.....
47	7	5	2	*2	.....	122	*3	.....	.....	.....	.....
48	*1	.....	.....	.....	.....	123	5	10	.....	.....	.....
49	*2	.....	.....	.....	.....	124	5	9	6	10	*1
50	*2	.....	.....	.....	.....	125	5	*3	.....	.....	.....
51	8	3	*8	.....	.....	126	*11	.....	.....	.....	.....
52	*5	.....	.....	.....	.....	127	*2	.....	.....	.....	.....
53	7	4	*1	.....	.....	128	*2	.....	.....	.....	.....
54	6	3	*7	.....	.....	129	*3	.....	.....	.....	.....
55	*1	.....	.....	.....	.....	130	*2	.....	.....	.....	.....
56	*1	.....	.....	.....	.....	131	5	6	*6	.....	.....
57	*1	.....	.....	.....	.....	132	*2	.....	.....	.....	.....
58	*1	.....	.....	.....	.....	133	5	*3	.....	.....	.....
59	5	3	5	*1	.....	134	*7	.....	.....	.....	.....
60	4	3	6	7	*9	135	*4	.....	.....	.....	.....
61	5	3	*5	.....	.....	136	5	*4	.....	.....	.....
62	5	*8	.....	.....	.....	137	12	7	4	*10	.....
63	7	5	10	8	14	138	13	*2	.....	.....	.....
64	7	5	*1	.....	.....	139	9	11	11	*2	.....
65	*2	.....	.....	.....	.....	140	5	10	*6	.....	.....
66	4	4	3	*14	.....	141	*2	.....	.....	.....	.....
67	5	3	*5	.....	.....	142	5	*0	.....	.....	.....
68	5	4	6	6	7	143	*3	.....	.....	.....	.....
69	5	3	*3	.....	.....	144	*2	.....	.....	.....	.....
70	4	4	5	*1	.....	145	5	10	*0	.....	.....
71	*5	.....	.....	.....	.....	146	*7	.....	.....	.....	.....
72	5	3	9	9	*12	147	*4	.....	.....	.....	.....
73	6	6	*3	.....	.....	148	7	*2	.....	.....	.....
74	5	3	7	*2	.....	149	5	*1	.....	.....	.....
75	4	3	*9	.....	.....	150	*2	.....	.....	.....	.....

CHART 8.—Length of instars of third generation—CONCLUDED.

Number.	1	2	3	4	5	Number.	1	2	3	4	5
151	*4					176	*6				
152	8	6	8	9	*2	177	*7				
153	*2					178	6	6	6	6	8
154	9	15	*9			179	*5				
155	5	12	12	*1		180	*4				
156	*2					181	*9				
157	10	4	5	6	9	182	6	*1			
158	*4					183	*7				
159	*1					184	*2				
160	8	*1				185	*4				
161	*1					186	*1				
162	*3					187	6	6	7	8	*3
163	*3					188	*4				
164	*5					189	*7				
165	*4					190	*5				
166	*5					191	*5				
167	*3					192	18	*1			
168	5	13	*2			193	*1				
169	9	11	5	*2		194	*4				
170	*4					195	3	*1			
171	*5					196	2	9	12	*4	
172	*3					197	*2				
173	*2					198	9	10	8	*4	
174	*2					199	9	*5			
175	6	11	7	7	*1	200	*8				

* Starred numbers indicate time of death.

DESCRIPTION OF THE NYMPHS. The first nymphs were a deep red color when fully developed and expanded, with small white markings and many white dots covering the body. As they grew larger and older, they became lighter in color, some of the fifth instars being almost pink. The terminal abdominal segment was usually pink in all instars. The red eyes and almost transparent legs and antennæ were constant throughout the nymphal life.

The first three instars bore metathoracic setæ. The first instar showed setæ on the last two abdominal segments only, the second instar showing them on seven segments of the abdomen, and the third instar showing not only the abdominal setæ but also the enlarged mesothoracic wing pads.

The fourth and fifth instars did not have metathoracic setæ, but did show the abdominal spines. In the fourth instar both the mesothoracic and metathoracic wing pads were apparent. In the fifth instar the wing pads extended to the fourth abdominal segment.

DESCRIPTION OF EGG AND NYMPHAL INSTARS.

Average individuals were selected for the descriptions of the various instars.

EGG. Length, 1 mm.; width, 0.25 mm. Elongate and slightly curved, the anterior end being somewhat less rounded. Color, light yellow, almost white at first; just before hatching becoming a deeper yellow; eye spots distinct two to three days before hatching.

FIRST INSTAR. Length, 1 mm.; width, 1.25 mm. Antennæ 2.25 mm., elongate white. Two metathoracic spines and four spines on each of last two abdominal segments white. Color, deep reddish purple, with many small white spots; eyes, brick red.

SECOND INSTAR. Length, 1.5 mm.; width, 15 mm. Four spines on last seven abdominal segments, two near the middle line, two following the lateral line. Mesothoracic wing pads evident; body long and narrow. Color, brick red, with increase of white spots, usually a narrow white band down middorsal line; last abdominal segment pale pink.

THIRD INSTAR. Length, 2.5 mm.; width, 0.75 mm. Abdominal spines present; mesothoracic wing pads covering first abdominal segment. Color, similar to second instar with enlargement of white spots; caudal edge of each abdominal segment showing white band.

FOURTH INSTAR. Length, 3 mm.; width, 1.25 mm. Metathoracic spines absent. Spines present on second and third pair of legs; abdominal segments with spines; mesothoracic and metathoracic wing pads covering first two abdominal segments. Color, abdomen darker red than third instar; thorax, pink.

FIFTH INSTAR. Length, 4 mm.; width, 1.5 mm. Metathoracic spines absent. Wing pads extending to fourth abdominal segment. Color, dorsally pale pink, becoming darker caudally on lateral portions of first five abdominal segments; wing pads white. Ventrally thorax darker than abdomen, latter in the first three segments white, last three pale pink.

ADULTS.

Male, length 4.5 mm.; width, 1.5 mm. Female, length 4.9 mm.; width 1.4 mm. The sexes cannot only be distinguished one from the other by their size, but also by their color. Both adults are typically brownish white in appearance, but the male shows the darker color of the two. Both the face and the vertex are of a pale yellow color.

NUMBER OF BROODS. There are three broods in a season. (Chart 9.) The nymphs of the first generation appear in early April. Adults of this generation were found in the field the first of June. From these, two more generations were reared in the insectary, the adults of the second generation appearing the middle of July and of the third generation the middle of August. The adults of the third generation were placed in hibernating cages in the early part of September.

Adults were never observed mating more than once. They were long-lived, one adult living from the middle of June until the middle of August. Both the nymphs and adults are found on the underside of the leaves, sometimes three or four on one leaf. Molting occurs also on the underside of the leaves where the molted skins are attached firmly. Plants growing in the direct sunlight are more apt to be infested than those in the shade.

CHART 9.—Showing the time of year in which eggs, nymphs, and adults of each generation appear.

Number of generation.	Eggs.	Nymphs.	Adults.
First	April 5 to April 15	April 11 to May 31	May 31 to June 10
Second	June 10 to June 20	June 20 to July 15	July 15
Third	July 16 to July 26	July 26 to September 2	September 2

STUDIES IN SPOTTING.

CHARACTER OF SPOTTING.

The puncture of *Eutettix chenopodii* on *Chenopodium album* and the other host plants produces crimson-colored spots. These are usually round in outline, especially when first made. They soon become wrinkled and raised; that is, the leaf tissue from above grows convex and from below concave. On the under surface of the leaf the color is somewhat lighter.

LOCATION OF SPOTS ON LEAVES. The spots may occur anywhere on the surface of the leaf depending upon the feeding of the nymph. They do not follow the venation of the leaf, and very pretty patterns are sometimes made by the nymphs as they gradually move in circles or lines across the surface.

Often the spots run together and cover a large part or even all of a leaf, both small and large ones often becoming entirely red. This is quite characteristic on pigweed and small *Chenopodium album* plants.

CURLING OF LEAVES. The margin of the affected leaves usually curls under and sometimes the whole leaf rolls up. Unless the plant is vigorous before becoming infected, it will be stunted. On young plants in the insectary, curling and stunting is very noticeable, and a number of the plants die from this cause. The time elapsing on chard leaves between the first curling and the final rolling up of

the leaf is eight days. Curling of leaves is followed by the gradual loss of the green color and the death of the leaf.

Stems of plants were sometimes affected, especially at the nodes.

Nymphs kept in vials were given fresh lamb's-quarter or pigweed daily. Spots were discernible the following day, although they were sometimes faint. Nymphs reared on entire plants made spots that were easily visible the following day. Faintness of the coloring in the first instance was due probably to the fact that the leaves were drying out in the vials. If many spots appeared on one leaf, at a time, they usually were small and about the size of a pin point.

LIFE HISTORY AND SPOTTING.

An attempt was made to discover the effect upon the leaves by the various instars. Each nymph as soon as hatched was placed in a small vial with a cotton stopper. Daily observations were made of the nature and the number of spots. Fresh leaves were fed the nymphs daily, also. All nymphs reaching the fifth instar were caged on potted plants to allow more freedom.

Two hundred individuals were started. From chart 10 it was found that from 111 individuals living through the first instar, 30 spotted the leaves with an average of 6.7 spots for each individual. In 5 cases the spots developed during the first twenty-four hours after being fed upon by the insect. It is of interest to note that 8 individuals lived through the first instar without producing any spots, although they were often noticed feeding.

Seventy-eight individuals lived through the second instar, with 47 of them spotting the leaf, an average of 12.6 spots to each. Again 5 individuals spotted the leaves during the first twenty-four hours of incubation, while 31 failed to produce any spots at all.

The average number of spots per individual produced in the third instar was increased to 24.4 each, with 39 out of 52 individuals spotting, and 13 apparently having no effect upon the leaves.

A decrease in the average number of spots by each individual was discovered in the fourth instar, the average being only 21.1 spots in each individual. This may be explained by the fact that all of the nymphs that spotted failed to live through the instar, 31 spotting and but 26 living through this instar. Eight nymphs spotted leaves during the first twenty-four hours.

An increase developed during the fifth instar, even though more individuals produced spotting than lived through the instar, the numbers being 17 to 11. However, these averaged 64.1 spots to

each nymph, with five spotting the leaf during the first twenty-four hours.

From these observations, it is evident that the ability to spot the leaves increases with the age of the nymph. Also the per cent of individuals causing injury and living through each instar increased with the age of the instar.

ADULTS AND SPOTTING.

One adult was caged on a beet plant from the first of June until the middle of August without spotting. Forty-six mated pairs of adults on beet, chard, lamb's-quarter and purslane for from four to eight weeks failed to show any spots. This would prove that the injury results from the nymphal stages entirely.

CHART 10.—Summary of spots made during each instar.

Number.	1	2	3	4	5	Number.	1	2	3	4	5
1	18					96			20	32	
2		1				98		7	19	*44	*261
4	2					99		1			
6	1			8		101		13	10		
11		21				103		1			
12	7					104		7	23	1	
14		16		11		105		10	13		
15		*44		6		106		7	*60		
16	3	8		*53	3	107			10	22	
17		9	9			110		1			
20					2	111		26	*58	*80	*77
22	5			15		112		6	16	21	
24	7					113		11	39	26	4
27	6			20		114		8	211		
31	6					116		3			
37	18					117		1			
43	15		5			118		14	9		
45	28			24		120		6	2	10	*221
46	4		2			121		7			
47	1		33			123		30			
51	7		*40			124		13	10	15	
54			12			125		11			
60	4		35	5	17	131		20			
61	4					134	2				
62	1					137		16	*57	1	
63			19	28	1	138	4				
64		7				139	14	17	5		
66	20			4		140		21	1		
68			20	30	*120	143		4			
69			2			148	6				
70			12			152		5			
72				17	29	154		8			
74			22			157	8	37	*74	*41	*125
75	1		8			168		13			
76			8			169		1			1
77			25			175		36			
78				8	97	177	2				
79				2		178		18	3	31	*95
80	1					187		27	24	16	23
83			3			192	5				
84			9	3		196		6			
86	1					198		22			
91			16			199		7			
92		19		28			2				
93		19		28	3	Totals....	†	†	†	†	†
94		1	4	25	2						
95		8									

* Where many spots appeared. † See Chart 11.

CHART 14.—Summary of spots made during each instar.

	First instar.	Second instar.	Third instar.	Fourth instar.	Fifth instar.
Total number of spots in each instar	203	594	952	655	*1091
Total number of individuals spotting in each instar	30	47	39	31	17
Average number of spots made by each individual	6.7	12.6	24.4	21.1	64.1
Total number of individuals living through each instar	111	78	52	26	11
Percent of individuals living through each instar that spotted	27.02	60.2	75	100	100

* Where many spots appeared.

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EXPLANATION OF PLATES.

PLATE LXVII

FIG. 1. Egg.
FIG. 2. Top of leaf showing position of egg.
FIG. 3. Edge of leaf showing position of egg.
FIG. 4. Leaf showing twelve eggs.
FIG. 5. Upper part of lamb's-quarter plant, badly infested.
FIG. 6. Leaf showing spotting and curling.
FIG. 7. First instar.
FIG. 8. Second instar.
FIG. 9. Third instar.
FIG. 10. Fourth instar.
FIG. 11. Fifth instar.
FIG. 12. Adult female.
FIG. 13. Adult male.
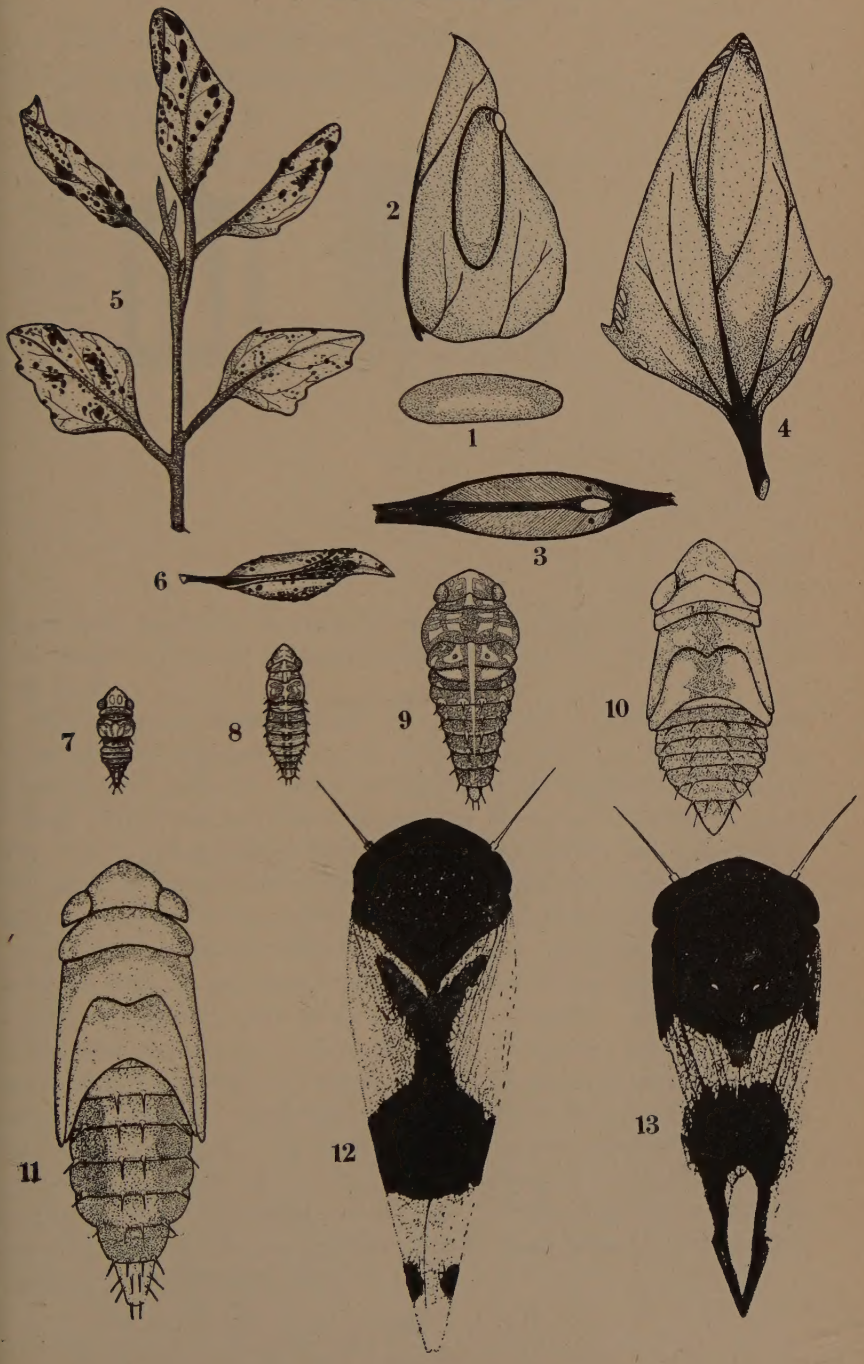
PLATE LXVII